

# ASSESSMENT OF A TRADITIONAL DOMESTIC PROJECT IN TIER-II CITY OF INDIA FOR STIMULATING GREEN RATED PROJECTS

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Received 28.06.2025.

Revised 19.08.2025.

Accepted 01.10.2025.

Keywords:

A B S T R A C T

*Tier-II city, environmental sustainability, Residential project, sustainable construction, Green rated project.*

Original research



*The challenges encountered within the construction industry continue to serve as a driving force for the implementation of sustainable development practices. Consequently, there is a growing inclination towards incorporating green technologies within our national framework. An esteemed entity in this domain is Green Rated Integrated Habitat Assessment (GRIHA), a prominent national body entrusted for green constructions in India. Despite the established efficacy of green construction, the number of GRIHA-registered projects remains relatively modest. The ongoing study evaluates a conventional residential venture in Bhopal (M.P.), a Tier-II city, based on 34 GRIHA criteria, aiming to elucidate strategies for securing 1–5-star ratings. This scholarly endeavor is poised to illuminate developers in Tier-II cities regarding deficiencies in construction practices that hinder green certification, thereby stimulating buyer interest in eco-friendly residential properties. The evaluation of the project, in accordance with GRIHA guidelines, sheds light on imperative tasks necessary to meet mandatory criteria.*

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## 1. INTRODUCTION

The global community is currently engaged in a profound struggle against a multitude of pressing challenges, such as the significant issues of global warming and various alterations in climate patterns, which collectively pose a considerable threat not only to ecosystems but also to the very existence of humanity itself. In particular, it is noteworthy that anthropogenic structures, especially buildings, constitute a major contributor to carbon dioxide emissions within urban environments, with these edifices being responsible for as much as 40% of the overall energy consumption in these metropolitan areas (Potbhare et al., 2009). In response to these alarming statistics, the concept of green buildings has emerged as a viable and sustainable solution aimed at alleviating carbon footprints, as they strategically leverage

renewable energy sources to significantly reduce environmental impact. These innovative structures not only advocate for the responsible utilization of natural resources but also emphasize the importance of employing eco-friendly materials, thereby contributing to the preservation and protection of our environment. By actively promoting the widespread adoption of green construction practices, it becomes increasingly plausible to effectively mitigate the adverse effects associated with climate change, thereby fostering a more sustainable future for all (Jain & Babu, 2025a). To further champion the cause of green construction, a comprehensive study has been conducted, focusing on a residential project situated in Bhopal, which is classified as a Tier-II city in India, in order to explore the potential for sustainable building practices. A thorough and critical examination of non-certified traditional residential projects is deemed essential to ascertain their level of compliance with the

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Green Rating for Integrated Habitat Assessment (GRIHA) standards, which will subsequently facilitate the identification of specific areas that require improvement to achieve at least a minimum 1-star rating as stipulated by GRIHA guidelines. This in-depth analysis will illuminate the extent to which traditional residential projects conform to either mandatory or partially obligatory criteria, providing valuable insights into their sustainability practices. However, there exist certain significant obstacles that Tier-II cities encounter in the country, which impede their ability to adopt and implement the guidelines set forth by agencies such as GRIHA. A selection of key reasons contributing to these challenges has been outlined below.

The specific challenges that Tier-II cities confront when attempting to meet GRIHA guidelines are multifaceted and complex. Firstly, there is a notable lack of support from governmental bodies in the form of incentives or streamlined processes for construction. It is crucial to acknowledge that not all state governments in India extend incentives, which serves as a primary reason for the limited number of green-rated projects being developed. In contrast to regions such as Delhi and Rajasthan, where governments provide an additional 5% Floor Area Ratio (FAR), the Maharashtra government has been proactive in offering relaxations in property taxes for green-rated projects, thus highlighting disparities in governmental support. Furthermore, many developers exhibit a reluctance to incur the additional costs associated with green residential projects, particularly in the absence of governmental backing for the installation of renewable energy systems, such as solar panels and water treatment plants (WTP), which are essential for the efficient reuse of available water resources. Additionally, there exists a significant lack of awareness and knowledge among various stakeholders regarding the long-term benefits associated with green residential projects, which hinders their adoption. Compounding this issue, developers often remain oblivious to the fact that by implementing a few minor modifications and adhering to the mandatory criteria outlined by GRIHA, their traditional projects can be effectively transformed into a 1-star green-rated project, thereby enhancing their sustainability profile (Jain & Babu, 2024a).

This research endeavor has been meticulously designed with specific objectives in mind, which, if successfully achieved, can contribute to a noble cause that addresses environmental concerns. The objectives of this research have been explicitly delineated below.

## 2. OBJECTIVES OF RESEARCH

The primary aim is to eliminate dependency on non-renewable resources while concurrently promoting the reutilization of renewable resources within the construction industry, thereby protecting the environment from further degradation and losses. Additionally, this research seeks to optimize the

utilization of advanced construction materials and techniques, ensuring that projects consume minimal energy while employing equipment capable of satisfying essential needs such as lighting, air conditioning, and other critical functions (Gogoin & Giri, 2017). Furthermore, it aims to maximize the effective management of water and wastewater treatment activities, ultimately providing safe and eco-friendly conditions for all inhabitants. Lastly, this research advocates for the initiation of government regulatory norms that can effectively promote the construction of green buildings by offering subsidies and financial aid to both developers and customers at the state and national levels.

The comprehensive details regarding existing subsidies, in terms of additional Floor Area Ratio (FAR), Floor Space Index (FSI), and incentives in the form of property tax relaxations, provided by various governmental bodies across India have been systematically presented in the table 1.

**Table 1.** Nature of Incentives provided by Indian States & Union Territories (Jain & Babu, 2024b).

S. No.	Name of State or Union Territory	Year of applicability	Nature of incentive
1	Andhra Pradesh	2015	Financial (Permit fees relaxation)
2	Chandigarh	2015	Mandatory to be done (Govt.)
3	Delhi	2013	Additional FAR & Ground coverage
4	Goa	2019	Mandatory to be done (T&CP)
5	Gujarat	2015	Additional FAR & FSI/Relaxation in consulting charges
6	Haryana	2017	Additional FAR & FSI/Mandatory for government & PSU's
7	Himachal Pradesh	2017	Additional FAR & FSI
8	Jharkhand	2017	Additional FAR & FSI
9	Kerela	2011	Mandatory to be done (PWD)
10	Maharashtra	2011	Relaxation in premium & property tax
11	Odisha	2018	Incentive as per state govt.
12	Punjab	2013	Additional FAR & FSI
13	Rajasthan	2014	Additional FAR & FSI
14	Sikkim	2015	Additional FAR & FSI
15	Uttar Pradesh	2011	Additional FAR & FSI
16	Uttarakhand	2017	Additional FAR & FSI/Mandatory for govt. buildings
17	West Bengal	2015	Additional FAR & FSI

## 3. LITERATURE REVIEW

The issue pertaining to the management of waste generated as a consequence of urbanization and development on a global scale can be adeptly tackled through the formulation and implementation of comprehensive standards that are focused on the principles of sustainable development. Extensive research efforts have been directed towards examining the potential incorporation of various waste materials into construction processes, thereby fostering a more circular economy. In addition, a thorough investigation into the myriad benefits as well as the potential challenges associated with the integration of waste materials into construction projects has been meticulously conducted, particularly through the detailed analysis of two enlightening case studies situated in India. By strategically integrating waste materials into residential construction projects, both governmental bodies and private sector organizations can significantly bolster their capacity to effectively manage construction waste while simultaneously developing and implementing suitable strategies that will guide their efforts in the future (Smith, 2015).

The adoption of sustainable construction materials is recognized as a crucial and indispensable component of environmentally conscious construction endeavors that are aimed at reducing the carbon footprint of building practices. The strategic utilization of sustainable materials is inextricably linked to a variety of fundamental considerations, which include not only the economic viability of such materials but also the imperative of environmental preservation and the promotion of social equity. Essential elements of any sustainable residential construction project encompass a myriad of enhancements aimed at improving water and energy efficiency, reducing the overall generation of waste at the construction site, enhancing the quality of indoor air, optimizing the design of heating, ventilation, and air conditioning (HVAC) systems, and engaging in meticulous planning of construction sites (Jain, 2024). The incorporation of industrial waste products, such as fly-ash and steel or iron slag, can play a pivotal role in preventing environmental degradation as well. In contemporary construction practices, fly-ash is increasingly being utilized in the production of mortar and bricks, which serves to effectively mitigate the detrimental effects of waste generated during infrastructure development. The principles underpinning sustainable development also necessitate the careful selection of materials that possess minimal adverse environmental impacts, while simultaneously emphasizing the importance of recyclability and reusability in the construction sector (Indraganti, 2010). In direct response to the energy crisis that emerged during the 1960s, a wealth of research initiatives has been dedicated towards enhancing energy efficiency and curtailing environmental degradation across various sectors. The construction industry faced analogous challenges, which ultimately led to the gradual emergence of the concept known as sustainable

construction. To facilitate the global dissemination of this pivotal concept, a variety of rating systems have been established across different regions worldwide. Researchers have diligently sought to articulate and define sustainable construction based on a set of criteria that have been adopted by diverse nations, reflecting a multifaceted understanding of what constitutes sustainability in the built environment. The advancement and progress of sustainable development are contingent upon a multitude of external factors, which encompass the development of relevant policies, the establishment of certification schemes, and the provision of economic incentives, as well as a variety of internal factors that include technological advancements and the ways in which users interact with green technologies (Ghaffarian Hoseini et al. 2013). At present, more than 48 distinct green building standards and 18 evaluation systems have been introduced globally by leading experts in the field. The effective implementation of green building technologies necessitates comprehensive enhancements in governmental policies alongside the creation of robust incentive frameworks that can support such initiatives. Moreover, there is a pressing need for improvements in the quality of professional assessments, the technical skills possessed by workers and staff, as well as the active engagement of relevant consultants who specialize in sustainable practices. Collectively, these concerted efforts will contribute significantly to national development, the formulation of sound and effective policies, and the encouragement of construction firms to surmount existing obstacles, thereby paving the way for extensive and impactful research endeavors in the foreseeable future (Chan et al., 2017).

A research framework that is predicated on Innovation Assessment and Governance Assessment tools has been employed to rigorously examine the various low-energy green building initiatives that are currently being undertaken in two major cities, namely Delhi and Singapore. The process of data collection for this investigation involved conducting in-depth interviews with a range of experts and participants who are intimately involved in the field of sustainable construction. The findings derived from this comprehensive study reveal that the governance conditions and frameworks in Singapore are markedly more robust and effective when compared to those observed in Delhi. In contrast, the governance policies and levels of support available for green building innovations in Delhi are characterized as being only moderately supportive, thereby indicating a need for further improvements and enhancements in this area (Jain et al., 2020). The construction sector bears equal responsibility for environmental degradation through material consumption and waste generation. The rapid urbanization observed in the nation has prompted technical officials and industry professionals to focus on sustainable construction initiatives. Consequently, urgent action is needed to address the barriers hindering the adoption of sustainable and eco-friendly construction practices within the country. To delve into the underlying

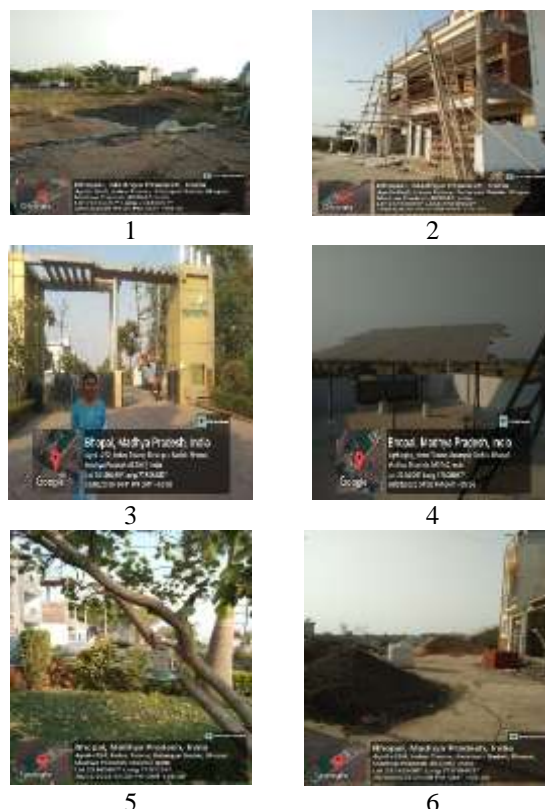
issues, a survey utilizing questionnaires was conducted among industry professionals and experts engaged in on-site activities. The survey responses provided by site engineers, project managers, planning engineers, supervisors, and trainee students unveiled crucial factors influencing sustainable construction. Key findings highlighted the lack of skilled labor, uninformed clients, and a general deficiency in knowledge among industry professionals concerning green construction technologies. Therefore, research consistently emphasizes that collaborative efforts from all stakeholders are essential for achieving success (Li et al., 2014).

#### An Examination of Sustainable Buildings in India

Sustainable buildings play a pivotal role in mitigating environmental harm by reducing reliance on fossil fuels during development. Furthermore, they enhance residents' quality of life through eco-friendly initiatives. Despite the limited research conducted in this area, it can be inferred that there is notable progress in the field. Scholars have endeavored to conclude by analyzing data from cities such as Delhi, the national capital. By categorizing the outcomes based on factors like age, gender, income, and education level, researchers can obtain precise insights into the increasing utilization of sustainable infrastructures. It has been demonstrated that knowledge and awareness among stakeholders serve as primary drivers in advancing sustainable buildings across India (Jain & Babu, 2024c).

#### 4. METHODOLOGY

To better understand the lacuna in traditional residential projects, it is essential to have an intensive study of this kind of project. The shortcomings of these projects will help to overcome them in the upcoming projects. Hence in the current research, a case study has been done on a traditional project of a Tier-II city (Bhopal) in India. The selected project Green Meadows is located on Bhojpur Road, Bhopal, and comprises 3, 4, and 5 BHK Singlex, Duplex and Bungalows with various modern facilities. Some of the highlights of the project site have been demonstrated in Figures 1-6 below.



Figures 1-6. Showing the selected site

The project has been evaluated and the shortcomings of each criterion have been listed below. The marks have been awarded as per the compliances given in the GRIHA manual.

The rating system as per GRIHA is shown below in table 2.

Table 2. Evaluation system of GRIHA (Jain, 2024).

S. No.	Points scored	Rating
1	50-60	One star
2	61-70	Two stars
3	71-80	Three stars
4	81-90	Four stars
5	91-100	Five stars

The major drawbacks and the remedial measures have been highlighted. The details of the different criteria of GRIHA have been highlighted in the table 3.

Table 3. Specifications based on GRIHA as per the different phases of building life cycle Jain (2024).

Criterion No.	Clause	Work requirements under criterion as per GRIHA
1	Site Planning phase (Partly Mandatory)	Site selection should comply with the provisions of eco-sensitive zone regulations, coastal zone regulations, and heritage areas (identified in the master plan)
2	Site Planning phase (Partly Mandatory)	To preserve existing vegetation using non-disturbance or damage to trees and other forms of vegetation during construction.
3	Site preservation phase	To lay the topsoil properly including soil stabilization and maintenance of adequate fertility of the soil supporting vegetative growth.
4	Site preservation phase	Minimizing the disruption of the natural ecosystem and designing to harness the maximum benefits of the prevailing micro-climate.
5	Landscape feature for green rating (Partly Mandatory)	Net paved area of site under parking, roads, paths, or any other use not to exceed 25% of site area.
6	Renewable energy-based systems phase	To meet minimum allowable luminous efficacy (as per lamp type) and make progressive use of a renewable-energy-based lighting system.

7	Site preservation phase	Minimizing road and pedestrian walkway length by appropriate planning and shading of pedestrian roads
8	Construction phase (Mandatory)	Ensuring cleanliness of the workplace for the disposal of waste and effluent, providing clean drinking water and latrines and urinals to workers.
9	Construction phase (Mandatory)	Ensuring proper screening, covering brick and loads of dusty materials, wheel washing facility, and water spraying facility on site.
10	Landscape feature for green rating	Reducing the water requirement for landscaping purposes by 30% or more.
11	Water management phase	Reducing building water use by applying low-flow fixtures and other tools by 25% or more. Using smart water meters can also help in water management.
12	Construction phase	Use materials such as pre-mixed concrete to prevent loss during mixing. Use recycled treated water and control the waste of curing water
13	Planning and building design phase (Mandatory)	Planning appropriately to reflect climate responsiveness, including adequate daylighting as well as efficient artificial lighting.
14	Planning and building design phase (Partly Mandatory)	Ensure that the building complies with the mandatory compliance requirement of the Energy Conservation and Building Code (ECBC) 2007 and meets thermal comfort conditions as per the National Building Code (NBC) 2005
15	Material selection phase	Using fly-ash, a minimum of 15% replacement of Portland cement with fly-ash, a minimum of 40% usage of fly-ash (by volume of materials used), and a minimum of 30% replacement of Portland cement with fly-ash (by weight of cement used) in plastering work.
16	Structural systems phase	Replace a part of the energy-intensive materials with less energy-intensive materials and/or utilize regionally available materials, which use low-energy/energy-efficient technologies.
17	Material selection phase	Minimum 70% in each of the three categories of interiors (internal partitions, paneling/false ceiling/interior wood finishes/in-built furniture door/window frames, flooring) from low-energy materials/finishes to minimize the usage of wood.
18	Renewable energy-based systems phase (Partly Mandatory)	Rated capacity of the proposed renewable energy system of internal lighting and space conditioning connected loads or its equivalent in the building ranging from 1% to 30%
19	Renewable energy-based systems phase	Meet 20% or more of the annual energy required for heating water through renewable energy-based water-heating systems for projects that have a hot water demand (minimum) of more than 500 liters per day.
20	Water management phase	Provide necessary treatment of water for achieving the desired concentration of effluents, to meet the disposal/reuse application standards.
21	Water management phase	Providing on-site wastewater treatment for achieving prescribed concentration, rainwater harvesting, and reuse of treated wastewater and rainwater for meeting the building's water and irrigation demands.
22	Construction phase	Ensure maximum resource recovery and safe disposal of wastes generated during construction and reducing the burden on landfill by recycling and safe disposal of segregated wastes.
23	Operation and Maintenance phase	Provision of providing multi-colored bins for waste segregation at source.
24	Operation and Maintenance phase	Allocate separate space for the collected waste before transferring it to the recycling/disposal stations if solid waste generation on site is more than 100 kg/day.
25	Landscape feature for green rating	Make arrangements for recycling of waste through local dealers and Zero waste generation through appropriate resource recovery measures.
26	Material selection phase	Zero/low-VOC paints: Zero/low-VOC paints for 100% of all paint used in the interior of the building and adhesives used are water-based rather than solvent-oil based/low in oil solvent content.
27	Planning and building design phase (Mandatory)	All the insulation used in the building is Chloro Fluoro Carbon (CFCs) and Hydro Chloro Fluoro Carbon (HCFCs) free and all the Heating Ventilation Air Conditioning (HVAC) and refrigeration equipment are CFCs free. The fire suppression systems and fire extinguishers installed in the building are free of halon
28	Operation and Maintenance phase (Mandatory)	Ensuring water from all sources (such as groundwater, municipal water, and treated wastewater) meets the water quality norms as prescribed in the Indian Standards for various applications [IS 10500-1991],
29	Planning and building design phase	The outdoor noise levels are within the acceptable limits as set in the Central Pollution Control Board (CPCB) and the indoor noise levels are within the acceptable limits as set in NBC 2005
30	Planning and building design phase (Mandatory)	The company policy for ban/prohibition of smoking within the building premises and zero exposure to tobacco smoke for non-smokers
31	Planning and building design phase	To ensure accessibility and usability of the building and its facilities by employees, visitors, and clients with disabilities.
32	Operation and Maintenance phase (Mandatory)	Energy audit report to be prepared by approved auditors of the Bureau of Energy Efficiency (BEE), Government of India
33	Operation and Maintenance phase (Mandatory)	Validate and maintain 'green' performance levels/adopt and propagate green practices and concepts for all electrical and mechanical systems to be maintained by the owner, supplier, or operator.
34	Innovation phase	Four innovation points are available alternative transportation, environmental education, company policy on green supply chain, life cycle cost analysis or any other criteria proposed by applicant.

The table 4 below gives the Marking scheme under the GRIHA checklist, for the project, evaluated based on the same.

*Assessment of a Traditional Domestic Project in Tier-II City of India For Stimulating Green Rated Projects*

**Table 4.** Marks gained by project as per 34 criteria of GRIHA (Jain, 2024; Jain & Babu, 2025b).

<b>Details of all Criterion</b>	<b>Remarks</b>
1. Selecting the site (Awarded Marks: 1)	a) The selected project site is appropriate and as per the City's Master plan. b) This project site is within a kilometer from the existing bus stop and away from eco sensitive zones.
2. Landscape protection during construction/compensatory depository forestation. (Awarded Marks: 3)	a) Natural vegetation was not damaged and trees are planted on the site to exceed ratio of 1:3 b) No soil or water pollution has been created due to spillage of construction material. c) No measurements have been taken on site to prevent erosion of soil. d) Designated area on site for gathering top soil and area for storing was demarcated.
3. Conserving soil (post-construction) (Awarded Marks: 2)	a) Excavated soil was reutilized on the project site. b) The soil was stabilized; its fertility was not hindered and is supporting vegetative growth.
4. Designing while including existing site features (Awarded Marks: 1)	a) All buildings on site have not gained benefits from the prevailing micro-climate i.e. no usage of solar or wind energy resources. b) Sustainable site planning was not achieved. c) No infrastructural component has harnessed hydrological, geologic and microclimatic features of the site.
5. Reduction in hard pavements on site (Awarded Marks: 1)	a) The net paved area including parks, roads, paths are more than specified limits of 25% b) The total paved shaded area is only 15% which is less than minimum specified value of 50%.
6. Uplifting external lighting system efficiency (Awarded Marks: 1)	a) Only outdoor security lighting fixtures are powered by solar energy (Minimum value is 25% of total connected load or 15% of total outdoor connected load) b) Solar-based Street lights, parking lights and landscape lighting facilities are not provided in campus.
7. Sustainable planning of utilities and optimizing on-site circulation efficiency (Awarded Marks: 2)	a) Consolidated pedestrian and automobile paths are developed b) Arrangements for the permanent shading of pedestrian roads are required. c) Site plan has been designed but road length and building footprints shall be further minimized.
8. Providing basic sanitation/safety facilities to the construction workers (Awarded Marks: 2)	a) Clean drinking water facilities were provided to all workers. b) Sanitation facilities of workers were appropriate; having adequate decentralized latrines and urinals. c) Workers were wearing helmets, hand gloves and gumboots during construction on site.
9. Minimizing air pollution during construction (Awarded Marks: 1)	a) Air pollution during construction was high as water was not sprinkled on site during unloading of materials like sand and coarse aggregates. b) Adequate water supply was not available for suppressing dust on site. c) Tarpaulin cloth was laid over the top of construction materials in trucks while bringing them on site and same was done during dumping of waste material.
10. Reducing the water requirements of landscape (Awarded Marks: 1)	a) The landscape water consumption was not minimized as open spaces were nearly developed as lawns. b) Details of plant species and area covered by them was not available. c) Sprinkler was used for watering landscape.
11. Minimizing the use of water in building (Awarded Marks: 1)	a) Low-flow fixtures were installed in Duplexes to reduce water consumption nearly 25%. b) Same shall be installed in all buildings of the project like club house, flats and temple. c) Design based calculations for reducing water use by up to 50% was not available.
12. Utilizing water efficiently during construction (Awarded Marks: 1)	a) Pre-mixed concrete was used in the project to reduce water losses during mixing. b) During curing, wastage of water was reduced. c) Potable water was used in the construction activity.
13. Designing building to reduce demand of non-renewable energy (Awarded Marks: 3)	a) Orientation of Duplexes and multi-unit buildings are optimized. Toilets, and staircases are along the eastern facades. b) The walls and roofs getting maximum solar exposures are not provided with shading device like Pergola, Jallis, trees or terrace garden. c) Appropriate shading for all the fenestrations receiving solar radiations is not provided. d) The total daylighted area of the buildings is less than 50% of the total living area.
14. Utilizing the building energy performance under specified limits of comfort. (Awarded Marks: 4)	a) The Energy Performance Index (EPI) i.e. annual energy consumption of a building (KWh) divided by the total built-up area is not reduced up to minimum specified value (40%). b) Energy Conservation and Building Code (ECBC) guidelines are not followed. (100% LED and motion sensor lights are not installed) c) In air-conditioned area, thermal comfort conditions are met for about 60% of occupied hours, in compliance with National Building Code (NBC 2005), the ideal value being 100% d) Quantification of energy usage for electrical and mechanical systems like air conditioning,
15. Consumption of fly-ash in building structure (Awarded Marks: 4)	a) The Portland Pozzolana cement (PPC) for making ready mix concrete contains only 5% fly ash. (Minimum criteria of 15% fly ash in cement as per GRIHA.) b) building blocks for the walls having nearly 20% Fly ash were constructed. (Minimum criteria of 40% replacement by volume of materials) c) Fly ash bricks were used in project. d) Fly ash about 15% by weight of cement was used for plastering (minimum 30% replacement criteria)

16. Ways of reducing construction time by utilizing technologies like pre-cast construction, RMC etc.) <b>(Awarded Marks: 1)</b>	a) Low energy technologies like pre stressed slabs, precast finished concrete blocks have not been adopted in this project. b) Lightweight concrete blocks have not been used over dense concrete blocks. c) Ready Mixed Concrete (RMC) has been utilized for saving time. d) Efficient technologies like traditional stone masonry, reinforced grouted brick masonry has not been adopted.
17. Using material having lower energy in interior of buildings <b>(Awarded Marks: 2)</b>	a) Low energy materials has been utilized in interiors like plywood prepared from sheets of veneer bonded with moisture-resistant adhesives. b) Composite wood products like particle boards have been used. c) Medium-Density Fiber board (MDF) made from wood fibres combined with wax and a resin binder have not been used. d) No recycled materials have not been utilized in interior wood finishes, flooring or doors and windows.
18. Utilizing renewable energy in construction <b>(Awarded Marks: 0)</b>	a) Solar or wind energy operated energy systems are not installed in project for utilising the renewable energy. b) Duplexes and multi-unit buildings have not been installed with roof top solar panels for generating renewable energy. c) Solar power operated street lights and parking lights facility is not provided in campus.
19. Using hot- water system based on renewable energy <b>(Awarded Marks: 0)</b>	a) Minimum 20% of the annual energy requirement for heating water (for all needs, like washing and bath rooms/toilets) is not supplied from renewable energy sources. b) Planning and layout of the solar powered energy system was not done. Size and annual energy generation data was unavailable. c) Calculations on energy required for heating water for all needs (in KWh) was unavailable.
20. Arrangements of treating waste water <b>(Awarded Marks: 1)</b>	a) Water testing reports were available. b) Waste water generation of project is above 10 KL/day but the necessary treatment of waste water is not being done. c) Waste water is discharged in municipal sewer lines.
21. Recycling & reusing water (even rainwater) <b>(Awarded Marks: 2)</b>	a) Rainwater harvesting facilities are provided only in Multi buildings fulfilling almost 25% of annual water requirements. b) Centralized rainwater storage tank of nearly 1 lac litre capacity is constructed. c) Recharging the aquifer or groundwater level is not being done. d) No steps are taken to prevent possible contamination of ground water by rainwater storage.
22. Ways of minimizing construction waste <b>(Awarded Marks: 1)</b>	a) The inert waste (concrete, bricks etc) generated on site was either reutilized or disposed to the local landfill sites. b) The construction wastage was segregated on separate paces on the site. c) The hazardous waste was collected separately consisting of oil, cans of paint and batteries were disposed with help of municipal corporation.
23. Segregating the construction waste <b>(Awarded Marks: 0)</b>	a) Specific locations, space and capacity for storing waste was not demarcated. b) For waste segregation like chemical, hazardous, and reusable categories, different coloured bins were not placed on site.
24. Storing and disposing construction wastes <b>(Awarded Marks: 1)</b>	a) Segregated waste was placed away from the unused construction material and sewer lines b) Hazardous waste was disposed separately via local municipal vehicle frequently. b) The disposal of construction waste from the site was done separately.
25. Ways of recovering resources from waste <b>(Awarded Marks: 0)</b>	a) Arrangements for recycling of construction waste by help of local vendors was not done. b) Waste treatment plant of specific capacity for disposing biodegradable waste was not planned and designed.
26. Using paints and products having low VOC. <b>(Awarded Marks: 2)</b>	a) Nerolac paints water-based acrylics were used in interior instead of oil-based paints. b) Water Based Adhesives were used in place of solvent based adhesives. c) Composite wood products containing traditional urea formaldehyde resin were used. (Not recommended)
27. Minimizing substances causing ozone depletion <b>(Awarded Marks: 0)</b>	a) Traditional glass fibre and wood fibre boards were used instead of Zero Ozone Depletion Potential. b) Advanced Halon free fire suppression system shall be installed in the campus.
28. Ways of maintaining water quality <b>(Awarded Marks: 1)</b>	a) Certificate from the local municipal authority for water quality was available for the municipal water supply. b) The underground water quality details were not compiled.
29. Maintaining noise in interior and exterior <b>(Awarded Marks: 0)</b>	a) No specific sound absorbent materials were used in the project. b) No special measures were taken to control outdoor noise inside the premises. c) Sound audit report conforming to the CPCB-Environmental Standards of noise at different
30. Neglecting the use of Tobacco and smoke <b>(Awarded Marks: 0)</b>	a) Absence of sign boards prohibiting the use of Tobacco and smoking in campus. b) Absence of designated smoking zone in the campus for both air conditioned and non-air-conditioner buildings.
31. Providing accessibility for persons with disability <b>(Awarded Marks: 0)</b>	a) Access to facilities like lifts were provided in all buildings but wheelchair was missing as recommended by National Building Code (NBC). b) Service like Ramps were inadequate in all the floors of buildings to eliminate 100% barriers for disabled person. c) Separate washroom for Divyang Jan was not prepared.

32. Conducting audits of energy, waste, and water. <b>(Mandatory with No Marks)</b>	a) Energy audit report by Energy auditor approved by the Bureau of Energy Efficiency, Government of India has not been prepared. b) Waste audit comprising of solid waste generation and disposal process has not been done. c) Sound audit report is not available.
33. Protocols for Operating and maintaining electrical and mechanical equipment <b>(Awarded Marks: 0)</b>	a) Project is not installed with digital smart water meters along main supply points to measure the total water consumption of the buildings. b) Regular monitoring of building's energy consumption by electrical smart meters and sub meters are not being done. c) No drawings and documents related to the best practices, Do's and Don'ts and maintenance requirements for the building's operation and maintenance has been prepared.
34. Adopting innovative methods (beyond 100) <b>(Awarded marks: 0)</b>	No innovative idea on the project site was implemented in addition to the traditional features.
<b>Total marks gained- 39</b>	

The selected project falls short of 1 star rating by 7 marks which can be recovered by taking suitable measures as specified by GRIHA. The graphical representation of the marks gained by traditional project is shown below from Figure 7-14.

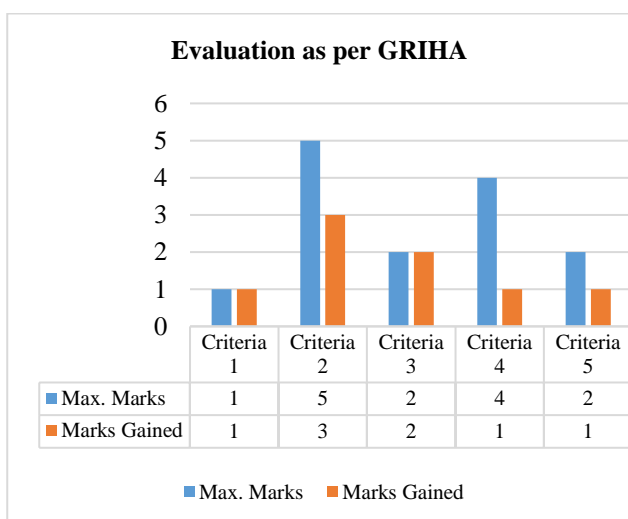


Figure 7. Comparative analysis of criteria 1-5 as per GRIHA

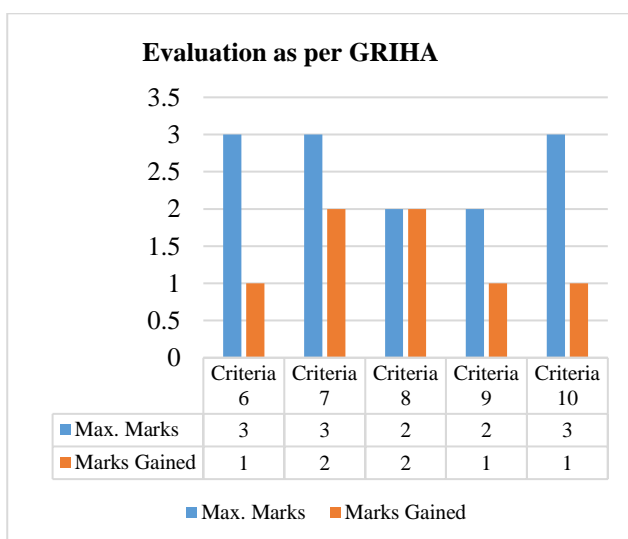


Figure 8. Comparative analysis of criteria 6-10 as per GRIHA

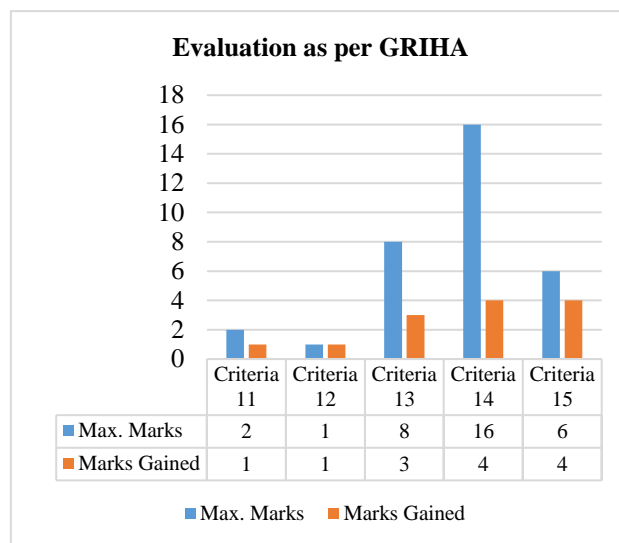


Figure 9. Comparative analysis of criteria 11-15 as per GRIHA

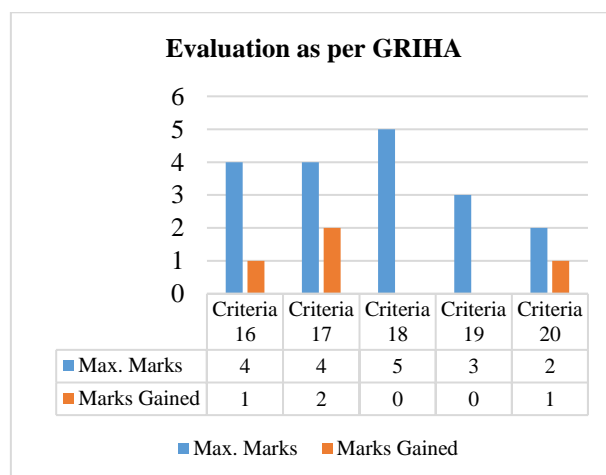


Figure 10. Comparative analysis of criteria 16-20 as per GRIHA

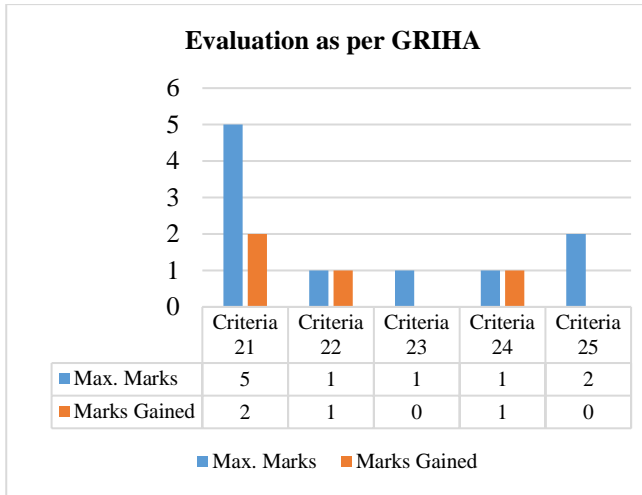


Figure 11. Comparative analysis of criteria 21-25 as per GRIHA

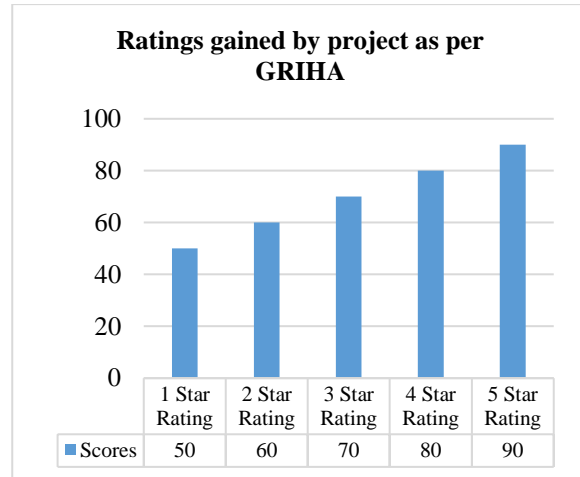


Figure 14. Comparative analysis of marks gained as per GRIHA rating system

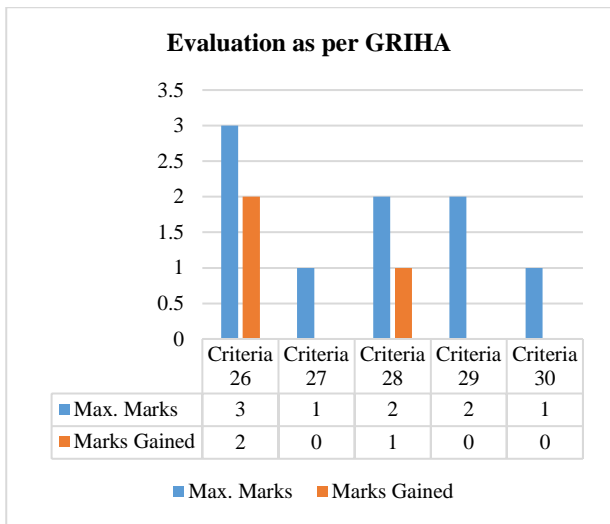


Figure 12. Comparative analysis of criteria 26-30 as per GRIHA

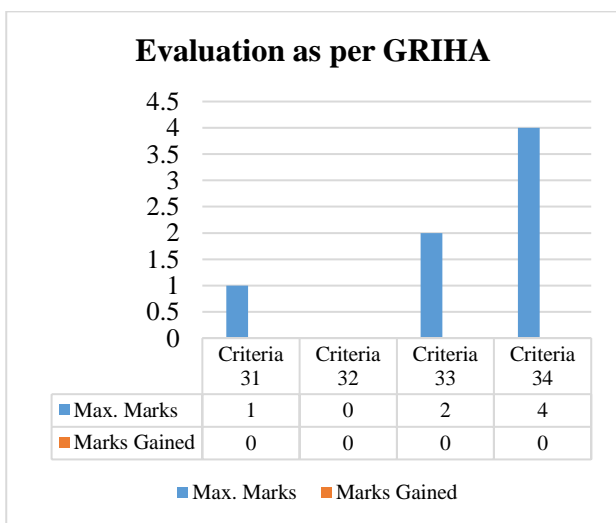


Figure 13. Comparative analysis of criteria 31-34 as per GRIHA

## 5. DISCUSSION AND ANALYSIS

The statistical data presented in the preceding paragraphs notably reveals that the chosen residential development project, upon evaluation, unfortunately falls significantly short of attaining a 1-star green rating, specifically by a concerning margin of 7 points when assessed against the rigorous GRIHA standards that are intended to promote sustainable construction practices. It is evident that the identified deficiencies inherent within the project can be effectively addressed and rectified through the implementation of targeted remedial actions, which are crucial for securing at least a minimal 1-star rating that reflects a commitment to environmental sustainability.1. It has been observed that during the operational phases involving the movement of vehicles entering and exiting the construction site, no measures were proactively implemented to mitigate air pollution levels or to enhance the overall air quality in the vicinity, thereby underscoring a significant oversight. Consequently, it becomes imperative that comprehensive and thorough cleaning procedures for the wheels of such vehicles are instituted as a paramount strategy to minimize the adverse effects of air pollution. Furthermore, during the critical activities of loading demolished waste or unloading construction materials at the site, it is essential to introduce the practice of sprinkling fresh water in order to effectively mitigate airborne pollutants and to align with the stringent requirements stipulated in criterion 9 of the GRIHA framework.

2. In order to accrue points under criterion 13 and to diminish the project's reliance on conventional energy sources that are often detrimental to the environment, it is advisable to implement measures such as shading or covering areas of the infrastructure that are excessively exposed to sunlight through the utilization of external structures, including but not limited to green facades or similar mechanisms designed for this purpose.

3. In strict accordance with criterion 16, it is essential to incorporate precast concrete components into the

construction process, which may include a variety of materials such as precast stone blocks, precast concrete blocks, precast finished concrete blocks, and lightweight concrete blocks, all of which should be favored over the more conventional and denser types of concrete blocks to enhance the overall sustainability of the project.

4. To ensure compliance with criterion 27, it is vital that enhanced fire safety provisions are introduced within multi-story buildings; this could involve the installation of an automatic sprinkler system that is activated by the generation of heat. Moreover, it is crucial to undertake concerted efforts aimed at reducing the reliance on equipment that emits chlorofluorocarbons (CFCs), particularly in the context of air conditioning and refrigeration systems, which are known to have detrimental effects on the ozone layer.

5. In order to adhere to criterion 28, it is necessary to obtain water quality testing reports from local municipal authorities, which will serve to verify that the project meets the water quality standards delineated in the Indian Standard code 10500, thereby ensuring the safety and sustainability of the water supply.

6. Raising awareness among all relevant stakeholders about the numerous hazards associated with tobacco consumption and smoking is of paramount importance for the successful attainment of points under criterion 30. To facilitate this goal, conducting workshops for workers and strategically installing informative signboards throughout the premises that proclaim "Ban on Tobacco & No Smoking Zone" can significantly contribute to promoting a healthier environment.

7. To effectively address the deficiencies identified under criterion 32, it is essential to conduct comprehensive Energy Audits, water quality audits, and solid waste audits at the site, all of which should be performed with the assistance of qualified experts within a two-year timeframe following the occupancy of the project.

8. The installation of smart water meters along the supply mains is not just recommended but necessary to significantly curb water wastage and to fulfill the

stringent requirements set forth in criterion 33, thereby promoting responsible water usage.

9. The implementation of these carefully considered recommendations and adjustments will undoubtedly facilitate compliance with the mandatory criteria established by GRIHA, ultimately paving the way for the attainment of at least a minimum 1-star rating. Additionally, similar investigative assessments can be conducted on traditional construction projects, and the findings can be compiled into a comprehensive report that is subsequently submitted to governmental bodies, thereby advocating for the enforcement of green construction practices in Tier-II cities across India, which is essential for protecting the environment from degradation.

10. Further research endeavors can be embarked upon regarding other types of traditional residential, commercial, or industrial projects to systematically identify deficiencies and to actively promote the adoption of green and sustainable construction technologies that are increasingly vital in the context of contemporary environmental challenges.

## 6. CONCLUSION

From the case study of the traditional residential project in this article, we conclude that there are several fields where residential projects need to work upon, so that they may be considered as green rated projects in India. The evaluated project received 39 marks out of 100 and is falling short by 11 marks to achieve even a one star rating as per the guidelines of GRIHA. Hence it is equally essential that the government promote green residential projects by providing suitable incentivization to the stakeholders. This will ultimately help in replacing the traditional residential projects into green residential projects in the near future, ultimately leading to sustainability.

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